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the chances that $p+1$, $p+2$, ... m ships will arrive. The sum of these added to (1) gives the chance that *at least* p ships out of m will arrive.

Also solved by *ELMER SCHUYLER*.

MISCELLANEOUS.

71. Proposed by **GUY B. COLLIER**, 1901 Union, 27 Middle Section of South College, Schenectady, N. Y.

Find the locus of any point on the front sprocket of a bicycle during one revolution of the hind wheel (any gear may be assumed).

I. Solution by **R. E. GAINES**, A. M., Professor of Mathematics, Richmond, Va.

Suppose the front sprocket revolves e times as fast as the hind wheel of the bicycle (if, to fix the idea, the gear be 70, then $e=\frac{2}{5}$), and take as axis of x the line on which the bicycle rolls, and as axis of y a line perpendicular to this, and passing through P when it was in its lowest position. Then let the hind wheel turn through an angle φ (the sprocket turning through an angle $e\varphi$) and the *center* of the sprocket has moved forward a distance $a\varphi$ and we obtain at once

$$x=a\varphi-r\sin(e\varphi),\quad y=a-r\cos(e\varphi),$$

where r=radius of sprocket, a=radius of hind wheel, and φ=angle through which the hind wheel has turned. Expressed as a single equation, this is

$$x=(a/e)\cos^{-1}\frac{a-y}{r}-r\sqrt{1-\left(\frac{a-y}{r}\right)^2}.$$

II. Solution by **G. B. M. ZERR**, A. M., Ph. D., Professor of Mathematics and Science, Chester High School, Chester, Pa.

Let O be the origin, $OF=x$, $PF=y$, P=any point in the front sprocket, g=gear, $AD=a$, radius of hind wheel, $AB=b$, $BP=c$, and also let $BE=AD=a$, $\angle MAD=\theta$.

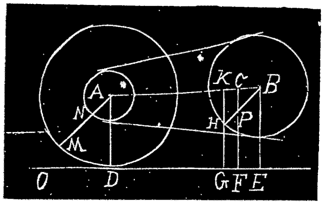
Then $BH/AN=g/2a$.

$\therefore\ \angle HBE=(2a/g)\theta$.

$\therefore\ x=OD+DE-FE=OD+AB-BC$.

$\therefore\ x=b+a\theta-c\sin(2a\theta/g)$.

$\therefore\ y=a-c\cos(2a\theta/g)$.



$$\therefore\ x=b+(\tfrac{1}{2}g)\cos^{-1}\left(\frac{a-y}{c}\right)-\sqrt{c^2-(a-y)^2}$$ is the equation to the locus.

s=length for one revolution of hind wheel.

$$\therefore\ s=(1/g)\int_0^{2\pi}\sqrt{a^2g^2+4a^2c^2-4a^2cg\cos(2a\theta/g)}\,d\theta$$

$$=(a/g)\int_0^{2\pi}\sqrt{(g+2c)^2-8cg\cos^2(a\theta/g)}\,d\theta.$$

Let $\frac{1}{2}\pi-\psi=a\theta/g$.

$$\therefore\ s=(g+2c)\int_{(\pi/2g)(g-4a)}^{\frac{1}{2}\pi}\sqrt{1-\frac{8cg}{(g+2c)^2}\sin^2\psi}\,d\psi$$

$$=(g+2c)E_{(\pi/2g)(g-4a)}^{\frac{1}{2}\pi}\left(\frac{2\sqrt{(2cg)}}{g+2c},\ \psi\right).$$

Also solved by ***WALTER H. DRANE.***

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PROBLEMS FOR SOLUTION.

ARITHMETIC.

118. Solution by J. F. TRAVIS, Student in Ohio State University, Columbus, O.

The present worth of a note due January 1, 1896, was \$74,200, when discounted at 4% true discount. The present worth of another note, due July 1, 1896, whose face value was the same as that of the first note, was \$68900 when discounted at 8% true discount. Find the face of the notes and the date when given, supposing the second note to have been given the same day the first note was. Solve by arithmetic.

119. Proposed by G. B. M. ZERR, A.M., Ph.D., Professor of Mathematics and Science, Chester High School, Chester, Pa.

The cost of an article is $\$1.\frac{9}{.001}$. The selling price \$1,000. What is the gain per cent.?

⁂ Solutions of these problems should be sent to B. F. Finkel not later than November 10.

ALGEBRA.

107. Proposed by CHARLES MYERS, Canton, Ohio.

Given $xyz=18$....(1); $x^2+y^2+z^2=33$....(2), and $(x^2-yz)^3+(y^2-xz)^3+(z^2-xy)^3-3(x^2-yz)(y^2-xz)(z^2-xy)=6561$....(3), to find x, y, and z.

108. Proposed by GEORGE LILLEY, Ph.D., LL.D., Professor of Mathematics, State University, Eugene, Or.

A gave two notes; one for a dollars at m per cent., and the other for b dollars at n per cent., annual interest. He is to make a monthly payment of c dollars. How much must be endorsed on each note in order to pay them off at the same time? What must be the endorsement on each if $a=1900$, $b=1800$, $m=6$, $n=7$, and $c=25$?

⁂ Solutions of these problems should be sent to J. M. Colaw not later than November 10.